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UNITED STATES ARMY
DIRECTORATE OF COMBAT DEVELOPMENTS
ANALYSIS DIVISION

VARIATION OF HISTORICAL CASUALTY RATES WITH BATTLE DATES

FINAL REPORT

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188
Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Combat Developments USASSC 6b. OFFICE SYMBOL (If applicable) ATSG-DDN	7a. NAME OF MONITORING ORGANIZATION TRAC-FBHN
6c. ADDRESS (City, State, and ZIP Code) Ft. Harrison 46216-5700	7b. ADDRESS (City, State, and ZIP Code) Director, TRAC-FBHN ATTN: ATRC-B Ft. Harrison 46216-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION USASSC 8b. OFFICE SYMBOL (If applicable) ATZI-CG	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Ft. Harrison 46216-5000	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Variation of Historical Casualty Rates with Battle Dates

12. PERSONAL AUTHOR(S)
Cathy J. Arebalo

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM Mar 90 TO Mar 91	December 1990	41

16. SUPPLEMENTARY NOTATION

17 COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Total Force Statistical Manpower Casualty Rates Planning

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This document is the final report on a study of the variation of historical casualty rates with battle dates.
Considerable disagreement exists regarding the relevance of historical casualty rates in planning for future battles because of the impact of technological advances. This study was designed to determine if technological advances have any significant relationship with casualty rates by statistically analyzing historical casualty rates over time from the period of 1937 - 1983. Hypothesis tests were performed to measure if a significant relationship exists between historical battle dates from 1937 - 1983; if there is a significant difference among casualty rates across different decades; and if there is a significant difference among casualty rates across different conflicts. Findings are based on an extensive statistical analysis of casualty rates and battle dates derived from the HERO database.
The conclusions offer an insight into considering the relevance of historical casualty rates as a predictor of future casualty rates, despite recent technological advances, within a conventional land battle scenario.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Cathy J. Arebalo	22b. TELEPHONE (Include Area Code) 317-542-3834 22c. OFFICE SYMBOL ATSG-DDN

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

UNCLASSIFIED

DECEMBER 1990

VARIATION OF HISTORICAL CASUALTY RATES WITH BATTLE DATES

FINAL REPORT

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ACKNOWLEDGMENTS

This study was initiated by TRADOC Analysis Command, Ft. Benjamin Harrison, and sponsored and performed by U.S. Army Soldier Support Center, Directorate of Combat Developments, Analysis Division, Ft. Benjamin Harrison.

This report has been approved by the Deputy Commander, Soldier Support Center, and the Director, TRADOC Analysis Command, Fort Benjamin Harrison.

The conclusions and recommendations of this study are based on data gathered by the Historical Evaluation Research Organization and analyzed by the Directorate of Combat Developments, Analysis Division, with analytical support from TRADOC Analysis Command, Ft. Benjamin Harrison.

Phil Vandivier (TRADOC Analysis Command-Ft. Harrison) and Anna Faye Brandenburg (DCD, Analysis Division) served as consultants during the study.

CONTENTS

ABSTRACT

This document is the final report on a study of the variation of historical casualty rates with battle dates.

Considerable disagreement exists regarding the relevance of historical casualty rates in planning for future battles because of the impact of technological advances. This study was designed to determine if technological advances have any significant relationship with casualty rates by statistically analyzing historical casualty rates over time from the period of 1937-1983. Hypothesis tests were performed to measure if a significant relationship exists between historical battle dates from 1937-1983; if there is a significant difference among casualty rates across different decades; and if there is a significant difference among casualty rates across different conflicts. Findings are based on an extensive statistical analysis of casualty rates and battle dates derived from the HERO database.

The conclusions offer an insight into considering the relevance of historical casualty rates as a predictor of future casualty rates, despite recent technological advances, within a conventional land battle scenario.

VARIATION OF HISTORICAL CASUALTY RATES WITH BATTLE DATES

EXECUTIVE SUMMARY

Considerable disagreement exists regarding the relevance of historical casualty rates in planning for future battles because of the impact of technological advances. This study addresses this controversy and has the objective of analyzing the relationship between casualty rates and historical battle dates.

The purpose of this study was to determine if technological advances have any significant relationship with casualty rates by statistically analyzing historical casualty rates over time from the period of 1937 - 1983.

A brief summary of the findings are as follows:

Grouped by Decade (40's thru 70's)

Attacker Casualty Rates

40's < 70's
50's < 60's
50's < 70's
All others - no significant difference

Defender Casualty Rates

40's < 60's
60's > 70's
All others - no significant difference

Grouped by War (WWII, Korean, 48, 67 & 73 Israeli)

Attacker Casualty Rates

WWII < 73 Israeli War
Korean < 67 Israeli War
Korean < 73 Israeli War
All others - no significant difference

Defender Casualty Rates

No significant difference

Trend Test on Ungrouped Data from 1937 - 1983

Attacker Casualty Rates

No significant upward or downward trend exists

Defender Casualty Rates

An upward trend of low magnitude exists

Although there are differences in casualty rates among wars (and decades), the analysis showed that there is no significant trend of magnitude in casualty rates from 1937-1983. Had the analysis showed there were no significant differences among wars and no trend over the years, clearly that would have been strong evidence to show that the advances in technology have not effected casualty rates. However, as it stands, the test for trend is sufficient to show that casualty rates have not risen with any degree of magnitude since 1937. By associating time with technological advances, we conclude that technological advances have no correlation with casualty rates and that the historical casualty rates are relevant to future casualty estimations.

The recommendations generated from this study are:

a. Although the evidence is not overwhelming, it is strong enough to support the belief that casualty rates have not risen despite technological advances. Any attempt to predict the future with disregard to the past should be reconsidered. Any model for the future must at least achieve its credibility based on the past.

b. A follow-up study on unconventional actions (which might include data from Vietnam) may produce information which would increase the accuracy of casualty rate estimations.

c. A follow-up study on other factors which may influence casualty rates could produce useful indicators for casualty estimations. Although some factors such as morale and political and religious motivation are not easily quantifiable, the task is not infeasible. Other factors such as training and force ratio are fairly easy to quantify.

VARIATION OF HISTORICAL CASUALTY RATES WITH BATTLE DATES

INTRODUCTION

1. Background:

Considerable disagreement exists regarding the relevance of historical casualty rates in planning for future battles.

One view maintains that historical casualty rates are irrelevant. This belief is based on the fact that a multitude of factors influencing combat effectiveness have improved over time. Weapons, training, and strategy are just a few of these factors. The issue then becomes the reliability of using historical casualty rates to predict casualties in tomorrow's battles when so many technological advances which influence combat effectiveness are continually changing and improving. Considering the changes in combat effectiveness which take place over time, this viewpoint contends that historical casualty figures are unsubstantiated as an indicator of future casualty rate estimations.

The other viewpoint believes that historical casualty rates are a usable indicator for casualty estimations. This belief is based on the fact that as combat effectiveness improves, this in turn spurs technological changes to defend against the latest innovations on the battlefield. For example, after the tank was developed, the antitank weapons were developed. In addition, this view asserts that although historical casualty rates may not be "perfect", it is better to derive casualty estimations on imperfect data than on conjecture.

Failure to resolve this problem will result in continued confusion as to the relevance of historical casualty rates in the formulation of casualty estimations. The need for this issue to be addressed is cited by Col. Trevor Dupuy [1] and by George Kuhn. [2]

This study addresses this controversy and has the objective of analyzing the relationship between historical battle dates and casualty rates. A direct correlation between the advancement of time and the advancement of technology is assumed. The argument for disregarding historical casualty figures will be supported if there is a significant variance of battle casualty rates during the period studied. However, if the variance is relatively small, historical casualty rates have not changed significantly in the past and can logically be used as predictors for the future despite technological advancements.

[1] Trevor N. Dupuy, Numbers, Predictions, & Wars (Indianapolis: Bobbs-Merril, 1979), p. 5.

[2] George W. S. Kuhn, "Ground Forces Casualty Rate Patterns" Logistics Management Institute #FP703TR1, Sept. 89, p. 3 - 3.

The data used for this study was derived from a collection of data on 601 battles by Col. Trevor N. Dupuy and his colleagues at the Historical Evaluation and Research Organization (HERO). From Dupuy's work, Robert McQuie of Concepts Analysis Agency assembled a database of 260 battles which took place since 1937. From these 260 battles, 45 characteristics were obtained. The following six characteristics were used for this study: date, length of the battle, number of attacking casualties, number of attacking men, number of defending casualties, and number of defending men.

2. Purpose:

The purpose of this study is to determine if technological advances have any significant relationship with casualty rates by statistically analyzing historical casualty rates over time from the period of 1937 - 1983.

3. Objectives:

a. To determine if a significant trend exists among historical attacker/defender casualty rates over time from the period of 1937 - 1983.

b. To determine if there is a significant difference among attacker/defender casualty rates across different decades (i.e. the 1940's, 50's, 60's, and 70's).

c. To determine if there is a significant difference among attacker/defender casualty rates across different conflicts (i.e. World War II vs. Korean War, Etc.).

4. Scope:

a. This study addressed only the relationship between casualty rates and historical battle dates.

b. This study pertained to conventional land battles only and does not consider other types of warfare such as nuclear, chemical, or biological warfare.

c. A battle is defined as a significant combat encounter between hostile forces at various echelons of aggregation up to and including corps, army, and army group.

d. Theatres included E. Europe, W. Europe, the Pacific, Korea, and the Middle East.

e. This study used battles in which the U.S. was not involved as well as battles in which there was U.S. involvement.

f. Attacker and defender were the only two battle postures considered.

g. A casualty is considered to be a soldier wounded or killed in action.

5. Limitations:

This study used the HERO database as its only source of data. The HERO database does contain some missing data points. However, this fact did not adversely affect this study because the characteristics examined in this study contain only 7 missing data points.

Some controversy exists over the HERO database because it was derived from a single body of research. However, it was used as a sole source because it is the only database of its kind known to be available at this time.

Only one data point was available from the Vietnam conflict.

The Arab-Israili data are known to be in error. Unfortunately, the degree of error and in what direction is in the hands of the Arabs and Israelis. However, for lack of better data these battles were used.

The samples size from the Korean War is too small for reliable statistical work. Accordingly, findings which made use of these data should be treated with caution.

6. Assumptions:

a. The HERO database is assumed to be accurate and reliable.

b. Technological advances progress as time progresses.

7. Methodology:

a. The attacker casualty rate will be calculated as (attacker casualties/attacker men) / # days of battle. This will derive the percent of attacker casualties per day to control for sizes of force and length of battle.

b. The defender casualty rate will be calculated as (defender casualties/defender men)/ # days of battle. This will derive the percent of defender casualties per day to control for sizes of force and length of battle.

c. The distribution from the variables (dates of the battles, the attacker casualty rate, and the defender casualty rate) will be tested for normality using the Goodness of Fit test.

d. Once it has been determined if the variable distributions are normal or not, the appropriate statistical test will be applied to the variables to:

(1) test the hypothesis that the correlation between attacker casualty rates and historical battle dates is approximately zero.

(2) test the hypothesis that the correlation between defender casualty rates and historical battle dates is approximately zero.

(3) test the hypothesis that there is no significant difference among the average attacker casualty rates for the decades of 1940, 1950, 1960, & 1970.

(4) test the hypothesis that there is no significant difference among the average defender casualty rates for the decades of 1940, 1950, 1960, & 1970.

(5) test the hypothesis that there is no significant difference between the average attacker casualty rates from World War II and the Korean War.

(6) test the hypothesis that there is no significant difference between the average defender casualty rates from World War II and the Korean War.

All tests will be performed using a .05 level of significance.

e. If the results in para 7d of the methodology reveal that a relationship does exist between any set of variables, the magnitude or strength of the relationship will be determined whenever appropriate.

f. Translate the results of para 7 d & e to determine whether or not historical casualty figures are relevant in the formulation of casualty estimations.

g. The practical significance of all findings to the Army will be discussed.

DATA ASSESSMENT

(For a detailed explanation of the data assessment see the technical appendix, C.)

1. Casualty Rate Calculations.

The attacker casualty rates were calculated for each battle as the percentage of attacker casualties per day using the following formula:

$$\frac{(\#\text{ of Attacker Casualties} / \#\text{ of Attacker Men})}{\#\text{ of Days of Battle}}$$

Similarly, the defender casualty rates were calculated as the percentage of defender casualties per day for each battle using the formula:

$$\frac{(\#\text{ of Defender Casualties} / \#\text{ of Defender Men})}{\#\text{ of Days of Battle}}$$

The casualty rates were formulated as a percentage of casualties per day to control for sizes of force and length of battle.

The results of the attacker and defender casualty rates for each battle are listed in Appendix B.

2. Descriptive Statistics and Normality of Data.

The attacker casualty rates involved 251 battles with a mean rate of 1.8% and a median rate of .9%. The minimum attacker casualty rate was .1% and the maximum attacker casualty rate was 31.7%.

The defender casualty rate data involved 253 battles with a mean of 5.7% and a median of 2.8%. The minimum defender casualty rate was .1% while the maximum was 96%.

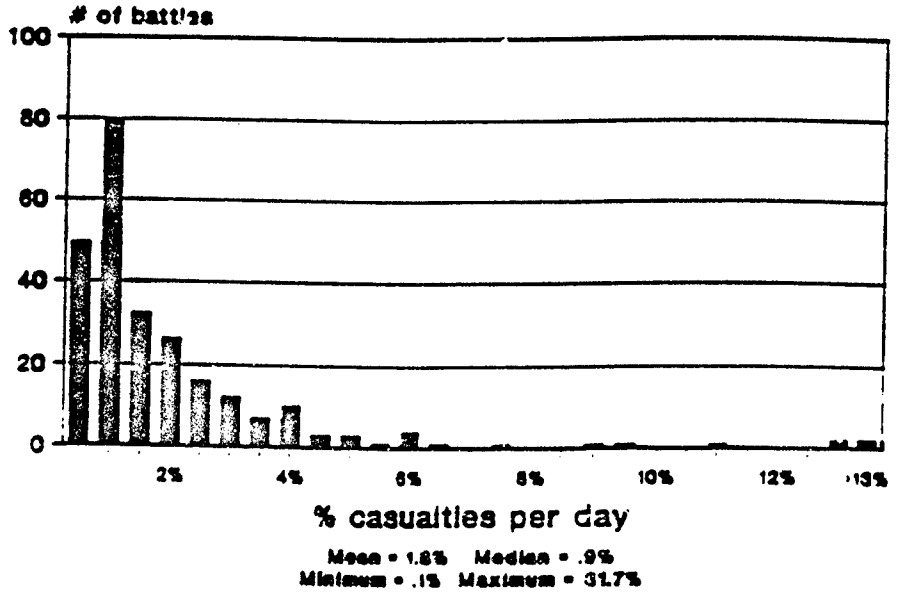
A frequency histogram for the attacker and defender casualty rates is displayed in figure 1. A Kolmogorov - Smirnov (K & S) Goodness of Fit Test was performed for a normal distribution on both the attacker and defender casualty rates. Both sets of data had a $p<.001$. Thus, the hypothesis that the data sets are normal was rejected at a 95% significance level and it was concluded that the attacker and defender casualty rates were not normal distributions.

3. Data Grouped by Decades.

The attacker and defender casualty rates were grouped by decades to include the 1940's, 50's, 60's, and 70's. Because the data is not from a normal distribution, a nonparametric test, the

Casualty Rate

Attacker



Defender

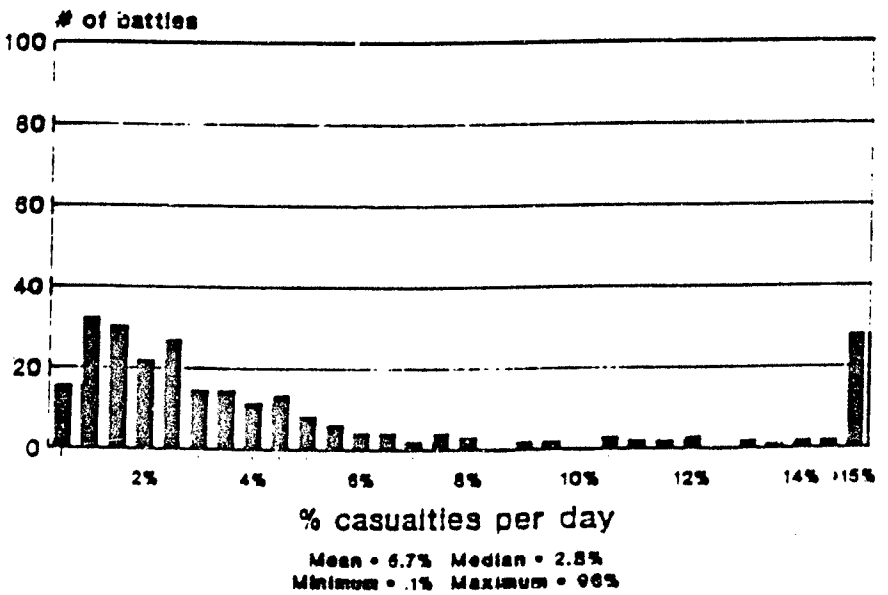


Figure 1

Kruskal - Wallis test, was used to test if any significant differences existed among the median casualty rates grouped by decades. A significance level of 95% was used. This test revealed that there are differences among both the attacker and defender casualty rates grouped by decades. The results of the test follow:

Attacker Casualty Rate Grouped by Decade

Median	# of Cases	Decade
0.85 %	172	40's
0.62 %	15	50's
1.57 %	23	60's
1.44 %	33	70's
	243 Total	

Corrected for Ties

Chi-Square	Significance
11.4057	.0097

Defender Casualty Rate Grouped by Decade

Median	# of Cases	Decade
2.25 %	172	40's
4.45 %	15	50's
3.68 %	23	60's
2.38 %	33	70's
	243 Total	

Corrected for Ties

Chi-Square	Significance
8.7289	.0331

See figure 2.

Since .0097 and .0331 are less than .05, we conclude a difference does exist among the decades for both postures of casualty rates. The analysis was continued to determine which decades differed. This involved a simultaneous multiple comparison of the decades with an overall confidence level of .80.

In comparing the attacker casualty rate, the analysis revealed that the median casualty rates of the 40's < 70's, the 50's < 60's, and the 50's < 70's. Within the defender casualty rates, the only significant difference among decades were the 40's < 60's and 60's > 70's.

Note: There is a larger variance among the defender casualty rates than the attacker casualty rates. For this reason, a larger

difference in the medians among the decades of the defending casualty rates was required for there to be a significant difference. In addition, the considerable variance among sample sizes imposes disparity on the results.

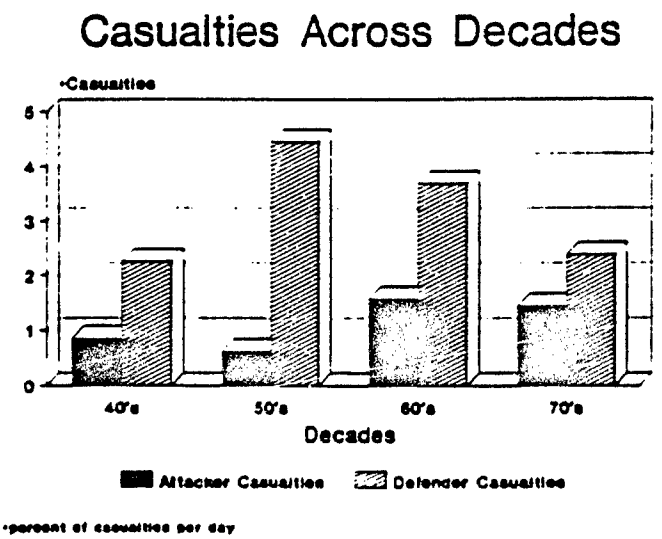


Figure 2

4. Data Grouped by Wars.

The data was also grouped by wars, although very little variation from the results of the groupings by decades was expected. The five different groups classified by war were the data from World War II, the 48 Israeli War, the Korean War, the 67 Israeli War, and the 73 Israeli War. Again a Kruskal - Wallis test was used to determine if significant differences exist within the attacker and defender casualty rates among wars. The data was ranked and grouped by war. A 95% confidence level was used to determine if a significant difference exists among wars. The results are listed below.

Attacker Casualty Rate Grouped by War

Median	# of Cases	War
0.76 %	170	WWII
1.25 %	9	48 Israeli
0.47 %	11	Korean
1.68 %	23	67 Israeli
1.53 %	33	73 Israeli
	246	Total

Corrected for Ties

Chi-Square	Significance
14.2449	.0066

Defender Casualty Rate Grouped by War

Median	# of Cases	War
1.99 %	171	WWII
2.00 %	9	48 Israeli
3.40 %	11	Korean
4.05 %	23	67 Israeli
2.38 %	33	73 Israeli
	247	Total

Corrected for Ties

Chi-Square	Significance
5.8334	.2119

See figure 3.

Since .2119 > .05, we failed to conclude that a significant difference exists among the median defender casualty rates grouped by war. Conversely, since .0066 < .05, we concluded that a significant difference does exist among the median attacker casualty rates grouped by war. A simultaneous multiple comparison, with a family confidence level of .80, was performed on the attac er posture. There was no need to do a multiple comparison on the defender posture since we were unable to show that a difference existed among wars.

In comparing the attacker casualty rates by war, the analysis revealed that the median casualty rate for World War II < 73 Israeli Wars, the Korean War < 67 Israeli Wars, and the Korean War < 73 Israeli Wars.

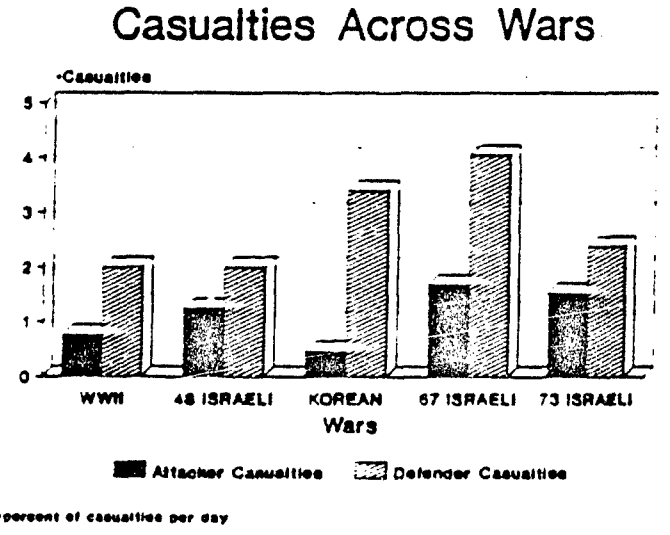


Figure 3

5. Ungrouped Casualty Rates from 1937 - 1983.

A statistical analysis was performed analyzing the data on an individual basis to determine if a trend (upward or downward) exists between the historical casualty rate postures and the battle dates from 1937 - 1983. The Spearman's Rank Correlation test was performed using a 95% level of significance. Pairing the attacker casualty rates with the battle dates produced an $r = .00488$, thus we were unable to conclude that a trend exists between the attacker casualty rates and battle dates from 1937 -1983. However, pairing the defender casualty rates with the battle dates yielded an $r = .277$. Using a correction factor for ties, $r = .267$. In this case, we can conclude that an upward trend does exist between defender casualty rates and battle dates from 1937 -1983. It should be noted that although this test statistic does conclude that a trend exists, because $r < .3$, this indicates that the magnitude or degree of association is low.

Note: Because nearly half of the data points are from World War II, we tried taking a random sample of size 30 from WWII (which is more comparable in sample size to the other wars). We then repeated the test for trend using the random sample from WWII and the other 4 wars to see if there were any indications of change in trend. This procedure produced a Rank Correlation Coefficient slightly lower than using the entire data set.

We also took a random sample of size 30 from WWII and then deleted the Korean War data to see if the lower casualty rates from the Korean War were possibly creating an anomaly that would result in a trend test showing no trend. Again the results remained relatively unchanged.

CONCLUSIONS and RECOMMENDATIONS

1. Conclusions:

A brief summary of the findings are as follows:

Grouped by Decade (40's thru 70's)

Attacker Casualty Rates

40's < 70's
50's < 60's
50's < 70's
All others - no significant difference

Defender Casualty Rates

40's < 60's
60's > 70's
All others - no significant difference

Grouped by War (WWII, Korean, 48, 67 & 73 Israeli)

Attacker Casualty Rates

WWII < 73 Israeli War
Korean < 67 Israeli War
Korean < 73 Israeli War
All others - no significant difference

Defender Casualty Rates

No significant difference

Trend Test on Ungrouped Data from 1937 - 1983

Attacker Casualty Rates

No significant upward or downward trend exists

Defender Casualty Rates

An upward trend of low magnitude exists

From the above results, one can easily see where the confusion and disagreements come from when discussing casualty rates. Given the many factors which influence casualty rates, this study will not even attempt to account for all the variations in casualty rates except for the influence of technology as it coincides to time.

Those who wish to tout that casualty rates are on the rise due to technological advances can support their statements by citing the attacking casualty rates grouped by war. But to simply say that advanced technology is the reason that the 73 Israeli War yielded

higher casualty rates than WWII and the Korean War is a misleading conclusion. To get a clearer analysis, one needs to look at the whole picture.

There often will be significant variation between wars. Anyone who has studied casualty rates knows that the impact of political motives, territorial threats, morale and training of the troops, the element of surprise, and religious morals greatly influence the casualty rates in a given war. The 73 Israeli War was heavily motivated by religious and political factors combined with a disadvantage in training and an advantage in the element of surprise for the Arab troops. Because there is no evidence to support that an upward trend exists in attacking casualty rates, more than likely it is these influences, and not technology, that yielded the higher attacking casualty rates in the 73 Israeli War.

It is also worth noting that even though there are statistically significant differences between attacking casualty rates among decades and wars, there is very little practical significance. The largest difference between medians among decades is .72% and among wars is .92%. A difference of less than 1% is very likely not practically significant when estimating the percent of casualties per day of a battle.

The results of the test for trend can also be misleading. To assume the median of all casualty rates as the "single" number to use in casualty estimations simply because there is no trend of any magnitude is almost as skewed as saying that casualty rates are on the rise. The reasons are the same. McQuie recommends in his benchmarks study to use "plausible" ranges from the data as a credibility criteria for modeling.[3]

Although there are differences in casualty rates among wars (and decades), the analysis showed that there is no significant trend of magnitude in casualty rates from 1937-1983. Had the analysis showed there were no significant differences among wars and no trend over the years, clearly that would have been strong evidence to show that the advances in technology have not effected casualty rates. However, as it stands, the test for trend is sufficient to show that casualty rates have not risen with any degree of magnitude since 1937. By associating time with technological advances, we conclude that technological advances have no correlation with casualty rates and that the historical casualty rates are relevant to future casualty estimations.

2. Recommendations:

The recommendations generated from this study are:

a. Although the evidence is not overwhelming, it is strong enough to support the belief that casualty rates have not risen despite technological advances. Any attempt to

[3] Robert McQuie, "Historical Characteristics of Combat for Wargames", Concepts Analysis Agency, July 1988, p.15.

predict the future with disregard to the past should be reconsidered. Any model for the future must at least achieve its credibility based on the past.

b. A follow-up study on unconventional actions (which might include data from Vietnam) may produce information which would increase the accuracy of casualty rate estimations.

c. A follow-up study on other factors which may influence casualty rates could produce useful indicators for casualty estimations. Although some factors such as morale and political and religious motivation are not easily quantifiable, the task is not infeasible. Other factors such as training and force ratio are fairly easy to quantify.

COMMENTS

This study was sent to Concepts Analysis Agency, TRADOC Analysis Command - White Sands Missile Range, and the Fort Benjamin Harrison Command Historian for review. Listed below are some of the reviewers responses resulting from this staffing.

1. Examining a longer span of time would have shown that casualty rates have trended steadily downward since around 1800. This fact confirms and extends the paper's findings that the increased lethality effects of modern weaponry have not been simply to increase casualty rates. They have had much more subtle (and poorly misunderstood) effects on military operations and tactics.

   Comment: Unfortunately, the only data available to perform this study was the HERO database. Had more time and resources been available to include a longer time span, the study may have revealed this trend.

2. The Arab-Israeli data are known to be in error. Unfortunately, the information on which to base a judgement of how large the errors are, and in what direction, is in the hands of the Arabs and the Israelis and has not been revealed to others. However, in terms of their elapsed times and the sizes of the forces involved, the Arab-Israeli clashes were mere skirmishes compared to the battles of other wars. Whether that would distort the historical trends is not known.

   Comment: This comment has been added to the limitations section of the study. Although this data may be in error, it is the best information available at this time and was not excluded from this study.

3. The sample size for the Korean War is too small for reliable statistical work. Accordingly, findings that make essential use of those data must be treated with caution.

   Comment: A cautionary statement was added to the study in the limitations section. In addition, the Korean War data was removed from the data base and the same tests were performed. As noted on page 10 this process had no significant impact on the results of the tests.

4. Even though the objectives of the study implied a confirmatory analysis, exploratory methods would have enhanced the analysis. Notched box plots would have

improved the comparative analysis among the rates for the four decades and five wars. The data was ideal for using a digidot plot.

Comment: These methods may have been utilized had more time been available.

5. Page viii and 13 states that any model must achieve its credibility based on the past. This is not always necessarily true.

Comment: Using historical data is widely accepted for the purposes of validation of models. Any other means of validating models is questionable and often highly scrutinized. This is not to say that there aren't other means for models to obtain credibility.

STUDY PLAN

VARIATION OF HISTORICAL CASUALTY RATES WITH BATTLE DATES

1. PURPOSE: To determine if technological advances have any significant relationship with casualty rates by statistically analyzing historical casualty rates over time from 1937 - 1983.

2. REFERENCES:

a. Dupuy, Trevor N., et al., Analysis of Factors That Have Influenced Outcomes of Battles and Wars: A Database of Battles and Engagements, Vol. IV - VI. Historical Evaluation and Research Organization, Dunn Loring, VA., Sept.,1984.

b. Myers, Raymond and Walpole, Ronald, Probability and Statistics for Engineers and Scientists. McMillian and Publishers, New York, N.Y., 1985.

3. TERMS OF REFERENCE:

a. Problem Statement.

Considerable disagreement exists regarding the relevance of historical casualty figures in planning for future battles.

b. Discussion of Problem.

Two viewpoints exist on the issue of the reliance of historical casualty figures as a determinant to future casualty estimations.

One view maintains that historical casualty figures are irrelevant. This belief is based on the fact that a multitude of factors influencing combat effectiveness have improved over time. Weapons, training, and strategy are just a few of these factors. The issue then becomes the reliability of historical casualty figures for tomorrow's battles when so many technological advances which influence combat effectiveness are continually changing and improving. In light of the changes in combat effectiveness which take place over time, this viewpoint contends that historical casualty figures are unsubstantiated as an indicator of future casualty rate estimations.

The other viewpoint believes that historical casualty rate figures are a usable indicator for casualty estimations. This belief is based on the fact that as combat effectiveness improves, this in turn spurs

technological changes to defend against the latest innovations on the battlefield. For example, after the tank was developed, the antitank weapons were developed. In addition, this view asserts that although historical casualty figures may not be "perfect", it is better to derive casualty estimations on imperfect data than on conjecture.

This study addresses the controversy by the objective of analyzing the relationship between historical battle dates and casualty rates. The argument for disregarding historical casualty figures will be supported if there is a significant variance of battle casualty rates during the period studied. However, if the variance is relatively small, historical casualty rates have not changed significantly in the past and can logically be used as predictors for the future.

c. Impact of problem.

Failure to resolve the problem will result in continued confusion as to the relevance of historical figures in the formulation of casualty estimations.

d. Objectives.

(1) This study will determine if a significant relationship exists between historical attack/defense casualty rates and battle dates from 1937 - 1983.
(2) This study will determine if there is a significant difference among attack/defense casualty rates across different decades (i.e. the 1940's, 50's, 60's, and 70's)
(3) This study will determine if there is a significant difference among attack/defender casualty rates across different conflicts (i.e. World War II vs. Korean War)

e. Scope.

(1) This study will address only the relationship between casualty rates and historical dates.
(2) This study pertains to conventional land battles only and does not consider other types of warfare such as nuclear, chemical, or biological warfare.
(3) A battle is defined as a significant combat encounter between hostile forces at various echelons of aggregation up to and including corps, army, and army group.
(4) Historical battle dates encompass the years 1937 - 1983.

(5) Theaters include E. Europe, W. Europe, the Pacific, Korea, and Israel.

(6) This study uses battles in which the U.S. was not involved as well as battles in which there was U.S. involvement.

f. Limitations.

This study will use the HERO database as its only source of data. The HERO database does contain some missing data points. However, this fact will not adversely affect this study because the characteristics examined in this study contain only 7 missing data points.

Only one data point is available from the last major U.S. conflict (Vietnam).

g. Assumptions.

(1) The HERO database is accurate and reliable.

(2) Technological advances progress as time progresses.

h. Essential Elements of Analysis (EEA).

(1) Is there a significant relationship between attacker casualty rates and historical battle dates?
(2) Is there a significant relationship between defender casualty rates and historical battle dates?
(3) Is there a significant difference among attacker casualty rates for different decades?
(4) Is there a significant difference among defender casualty rates for different decades?
(5) Is there a significant difference between attacker casualty rates for World War II and the Korean War?
(6) Is there a significant difference between defender casualty rates for World War II and the Korean War?

i. Constraints.

The study will be conducted using no more than .5 PSY.

j. Alternatives.

N/A.

k. Measures of Effectiveness (MOE).

N/A.

1. Methodology.

(1) The attacker casualty rate will be calculated as (attacker casualties/attacker men) / # days of battle. This will derive the percent of attacker casualties per day to control for sizes of force and length of battle.

(2) The defender casualty rate will be calculated as (defender casualties/defender men)/ # days of battle. This will derive the percent of defender casualties per day to control for sizes of force and length of battle.

(3) The distribution from the variables (dates of the battles, the attacker casualty rate, and the defender casualty rate) will be tested for normality using the Goodness of Fit test.

(4) Once it has been determined if the variable distributions are normal or not, the appropriate statistical test will be applied to the variables to:
   (a) test the hypothesis that the correlation between attacker casualty rates and historical battle dates is approximately zero.
   (b) test the hypothesis that the correlation between defender casualty rates and historical battle dates is approximately zero.
   (c) test the hypothesis that there is no significant difference among the average attacker casualty rates for the decades of 1940, 1950, 1960, & 1970.
   (d) test the hypothesis that there is no significant difference among the average defender casualty rates for the decades of 1940, 1950, 1960, & 1970.
   (e) test the hypothesis that there is no significant difference between the average attacker casualty rates from World War II and the Korean War.
   (f) test the hypothesis that there is no significant difference between the average defender casualty rates from World War II and the Korean War.

   All tests will be performed using a .05 level of significance.

(5) If the results in step 4 of the methodology reveal that a relationship does exist between any set of variables, the magnitude or strength of the relationship will be determined whenever appropriate.

(6) Translate the results of step 4 & 5 to determine whether or not historical casualty figures are relevant in the formulation of casualty estimations.

(7) The practical significance of all findings to the Army will be discussed.

m. Related Studies.

(1) Burt, Jeffrey, et. al., Distribution of Combat Casualties by Causative Agents. Research Analysis Corporation, McClean, VA., March 1965.
(2) Helmbold, R.L., Do Battles and Wars Have a Common Relationship Between Casualties and Victories? Concepts Analysis Agency, Bethesda, MA., Nov. 87.
(3) McQuie, Robert, Historical Characteristics of Combat for Wargames (Benchmarks). Concepts Analysis Agency, Bethesda, MA., July 1988.

4. ENVIRONMENTAL/THREAT CONSIDERATIONS: All standard combat development scenarios employed by existing Army models will be considered in this study.

5. SUPPORT AND RESOURCE REQUIREMENTS:

a. Support Requirements.

(1) AD will perform analysis and manage study.

b. Resource Requirements.

.4 PSY AD
.1 PSY TRAC-FBHN
.5 PSY TOTAL

c. Data Requirements.

TRAC-FBHN will supply casualty factors from HERO database.

6. ADMINISTRATIVE:

a. Milestone Schedule.

30 MAR 90 Draft Study Plan
15 APR 90 Final Study Plan
30 APR 90 Submit study plan for approval by Director, DCD
15 MAY 90 Submit study plan for approval by Director, TRAC-FBHN
30 MAY 90 DD 1498 to DTIC
1 JULY 90 Statistical analysis complete
1 SEPT 90 Draft Study Report
1 OCT 90 Staff Draft Report
15 OCT 90 Final Study Report
1 NOV 90 Submit Report for Certification by Director, TRAC-FBHN

31 DEC 90 Submit for approval by CG, SSC
15 JAN 91 Submission of final report to DTIC, Army Library

b. Control.

Analysis Division, Directorate of Combat Development, Soldier Support Center will perform the study. TRAC-FBHN will approve the study plan and certify the final report. CG, SSC will approve the final report.

c. Study Project Officer.

Ms. Cathy J. Arebalo, Analysis Division, DCD.

7. CORRELATION:

a. AR 5-5 Category: g
b. Study priority within TRADOC study program: TBD

BENCHMARKS (HERO DATBASE)

Theater	Date	Nations Atkr	Dfdr	Days	Casualties Atkr	Dfdr	Attacker Men	Defender Men	Attacker Cas. Rate	Defender Cas. Rate
Spain	Mar-37	Ital	SRpb	5	6,460	6,660	52,000	100,000	2.48%	1.33%
W.Europe	May-40	Ger	Fr	12						
W.Europe	May-40	Ger	Fr	2	800	5,000	48,000	60,000	0.83%	4.17%
W.Europe	May-40	Ger	Fr	5			17,000	12,143		
W.Europe	May-40	Brit	Ger	2		410	11,821	18,000		1.14%
W.Europe	Jun-40	Fr	Ger	1			189	189		
Manchuria	Jul-38	Jap	USSR	1	178	350	1,410	1,460	12.62%	23.97%
Manchuria	Aug-38	USSR	Jap	2	400	41	4,000	3,010	5.00%	0.68%
Manchuria	Sep-38	USSR	Jap	5	4,000	1,100	20,000	8,000	4.00%	2.75%
Manchuria	May-39	Jap	USSR	2	278	250	1,300	1,228	10.69%	10.18%
Manchuria	Aug-39	USSR	Jap	12	10,000	11,500	57,000	30,000	1.46%	3.19%
Manchuria	Aug-45	USSR	Jap	8	10,000	36,000	147,000	75,000	0.85%	6.00%
Malaysia	Dec-41	Brit	Jap	1	600	1,200	7,000	12,000	8.57%	10.00%
Finland	Dec-39	Finn	USSR	29	2,670	19,600	9,000	29,954	1.02%	2.26%
Russia	Jun-41	Ger	USSR	5	4,000	88,000	132,000	150,000	0.61%	11.73%
Russia	Sep-41	Ger	USSR	65	253,000	885,000	1,100,000	1,372,200	0.35%	0.99%
Russia	Dec-41	USSR	Ger	34	139,000	85,300	1,060,300	880,000	0.39%	0.29%
Russia	Aug-42	USSR	Ger	8	21,300	6,530	54,180	45,897	4.91%	1.78%
N.Africa	Aug-42	Ger+	Brit	3	2,940	1,750	124,000	120,000	0.79%	0.49%
N.Africa	Oct-42	Brit	Ger+	13	13,000	16,000	220,476	105,223	0.45%	1.17%
N.Africa	Oct-42	Brit	Ger+	3	6,140	3,695	220,476	105,223	0.93%	1.17%
N.Africa	Oct-42	Brit	Ger+	7	3,000	4,500	214,336	101,528	0.20%	0.63%
N.Africa	Nov-42	Brit	Ger+	3	4,420	7,800	211,000	97,000	0.70%	2.68%
N.Africa	Nov-42	Ger	US	1	27	21	465	188	5.81%	11.17%
N.Africa	Mar-43	Ger	US	1	450	203	10,300	22,000	4.37%	0.92%
N.Africa	Apr-43	US	Ger	11	1,120	605	24,100	5,000	0.42%	1.10%
Italy S	Sep-43	Brit	Ger	3	1,154	100	12,917	4,250	2.93%	0.78%
Italy S	Sep-43	Brit	Ger	3	1,530	120	12,917	4,250	3.95%	0.94%
Italy S	Sep-43	US	Ger	1	251	60	12,447	8,390	2.02%	0.72%
Italy S	Sep-43	Ger	Brit	4	1,112	1,639	14,730	11,230	1.89%	3.65%
Italy S	Sep-43	Ger	Brit	4	900	1,160	15,000	12,917	1.50%	2.25%
Italy S	Sep-43	Ger	Brit	2	702	317	14,733	12,691	2.38%	1.25%
Italy S	Sep-43	Brit	Ger	2	300	110	14,730	6,995	1.02%	0.79%
Italy S	Sep-43	US	Ger	2	386	120	15,576	6,702	1.24%	0.90%
Italy S	Sep-43	Ger	Brit	2	400	255	13,300	18,912	1.50%	0.67%
Italy V	Oct-43	Brit	Ger	3	370	80	14,557	8,068	0.83%	0.33%
Italy V	Oct-43	US	Ger	2	140	52	18,210	6,435	0.38%	0.40%
Italy V	Oct-43	Brit	Ger	1	420	94	16,857	8,000	2.49%	1.18%
Italy V	Oct-43	Brit	Ger	2	500	40	21,265	8,160	1.18%	0.25%
Italy V	Oct-43	US	Ger	2	133	130	21,265	6,435	0.31%	1.01%
Italy V	Oct-43	US	Ger	2	267	76	18,480	7,250	0.72%	0.52%
Italy V	Oct-43	US	Ger	3	65	103	17,034	5,152	0.13%	0.67%
Italy V	Oct-43	Brit	Ger	2	125	45	14,600	8,138	0.43%	0.28%
Italy V	Oct-43	Brit	Ger	2	200	56	16,400	7,239	0.61%	0.46%
Italy V	Oct-43	Brit	Ger	3	220	138	17,500	8,128	0.42%	0.57%
Italy V	Oct-43	Brit	Ger	3	75	44	14,000	8,088	0.18%	0.18%
Italy V	Nov-43	US	Ger	2	416	185	16,870	6,321	1.23%	1.46%
Italy V	Nov-43	Brit	Ger	3	240	33	19,513	6,750	0.41%	0.16%
Italy V	Nov-43	US	Ger	2	361	142	16,600	6,566	1.09%	1.08%
Italy V	Nov-43	US	Ger	2	155	25	17,404	6,566	0.45%	0.19%
Italy V	Nov-43	Ger	Brit	3	34	310	7,942	5,200	0.14%	1.99%
Italy V	Nov-43	US	Ger	3	165	118	16,350	7,942	0.34%	0.50%
Italy V	Dec-43	Brit	Ger	2	250	20	17,765	7,588	0.70%	0.13%

Theater	Date	Nations Atkr	Ofdr	Days	Casualties Atkr	Ofdr	Attacker Men	Defender Men	Attacker Cas. Rate	Defender Cas. Rate
Italy V	Dec-43	Brit	Ger	4	550	141	20,744	3,288	0.66%	1.07%
Italy V	Dec-43	US	Ger	2	80	20	5,551	3,288	0.72%	0.30%
Italy A	Jan-44	Brit	Ger	2	1,158	130	19,350	6,750	2.99%	0.96%
Italy A	Jan-44	Ger	Brit	1	366	62	15,317	17,976	2.39%	0.34%
Italy A	Feb-44	Ger	Brit	2	1,318	1,450	26,029	9,834	2.53%	7.37%
Italy A	Jan-44	Brit	Ger	3	742	221	17,766	15,098	1.39%	0.49%
Italy A	Feb-44	Ger	Brit	2	341	369	26,490	4,515	0.64%	4.09%
Italy A	Feb-44	Ger	Brit	3	167	107	7,418	5,000	0.75%	0.71%
Italy A	Feb-44	Ger	Brit	1	270	311	27,518	17,730	0.98%	1.75%
Italy A	Feb-44	US	Ger	2	101	206	13,400	7,077	0.38%	1.46%
Italy A	Feb-44	Ger	US	4	2,238	1,018	41,974	20,496	1.33%	1.24%
Italy A	Feb-44	Ger	Brit	4	1,451	1,693	21,478	9,761	1.69%	4.34%
Italy A	Feb-44	Ger	US	3	265	403	15,367	19,613	0.57%	0.68%
Italy R	May-44	US	Ger	3	531	1,035	18,702	9,250	0.95%	3.73%
Italy R	May-44	US	Ger	2	1,974	720	17,970	8,141	5.49%	4.42%
Italy R	May-44	US	Ger	2	537	442	16,458	7,500	1.63%	2.95%
Italy R	May-44	US	Ger	2	343	730	18,308	8,215	0.94%	4.44%
Italy R	May-44	US	Ger	3	405	721	23,190	7,627	0.58%	3.15%
Italy R	May-44	US	Ger	2	203	332	13,095	4,563	0.78%	3.64%
Italy R	May-44	US	Ger	3	257	380	17,912	6,650	0.48%	1.90%
Italy R	May-44	US	Ger	2	287	380	18,030	6,653	0.80%	2.86%
Italy R	May-44	Brit	Ger	2	234	468	17,345	12,569	0.67%	1.86%
Italy R	May-44	Brit	Ger	2	194	107	17,343	11,343	0.56%	0.47%
Italy R	May-44	US	Ger	3	710	1,355	22,374	12,815	1.06%	3.52%
Italy R	May-44	US	Ger	3	1,524	1,617	19,971	11,928	2.54%	4.52%
Italy R	May-44	US	Ger	3	162	277	17,925	6,957	0.30%	1.33%
Italy R	May-44	US	Ger	1	767	1,319	20,683	12,327	3.71%	10.70%
Italy R	May-44	US	Ger	3	517	580	19,047	10,593	0.90%	1.83%
Italy R	May-44	US	Ger	2	263	598	18,000	13,715	0.73%	2.18%
Italy R	May-44	Brit	Ger	3	245	374	15,557	7,659	0.52%	1.63%
Italy R	May-44	US	Ger	3	1,304	1,379	29,711	15,801	1.46%	2.91%
Italy R	May-44	US	Ger	4	825	698	17,300	6,108	1.19%	2.86%
Italy R	Jun-44	US	Ger	2	329	1,178	22,641	13,012	0.73%	4.53%
Italy R	Jun-44	US	Ger	2	316	884	23,604	19,255	0.67%	2.30%
Italy R	Jun-44	US	Ger	2	710	568	26,607	10,111	1.33%	2.81%
Italy R	May-44	Brit	Ger	2	572	850	38,011	10,855	0.75%	3.92%
Italy N	Sep-44	US	Ger	5	560	560	15,721	3,700	0.71%	3.03%
W.Europe	Jul-44	US	Ger	8	2,777	2,350	18,228	7,500	1.90%	3.92%
W.Europe	Jul-44	Brit	Ger	3	4,011	5,000	76,213	57,300	1.75%	2.90%
W.Europe	Jul-44	US	Ger	3	1,510	5,000	126,000	30,700	0.40%	5.43%
W.Europe	Aug-44	Ger	US	6	4,800	2,673	25,500	27,673	3.14%	1.61%
W.Europe	Aug-44	US	Ger	1	113	579	15,646	8,325	0.72%	6.95%
W.Europe	Aug-44	US	Ger	3	99	362	17,232	6,000	0.19%	2.01%
W.Europe	Aug-44	US	Ger	3	234	906	40,619	15,000	0.19%	2.01%
W.Europe	Sep-44	US	Ger	6	1,647	1,700	59,631	41,500	0.46%	0.68%
W.Europe	Sep-44	US	Ger	1	359	210	60,794	39,580	0.59%	0.53%
W.Europe	Sep-44	Ger	US	4	779	119	7,500	4,800	2.60%	0.62%
W.Europe	Oct-44	US	Ger	6	1,477	3,616	32,283	19,632	0.76%	3.07%
W.Europe	Nov-44	US	Ger	12	3,683	3,000	20,493	20,250	1.50%	1.23%
W.Europe	Nov-44	US	Ger	5	4,265	4,880	99,583	23,588	0.86%	4.14%
W.Europe	Nov-44	US	Ger	2	720	446	43,587	11,185	0.83%	1.99%
W.Europe	Nov-44	US	Ger	3	1,006	197	25,881	7,555	1.30%	0.87%
W.Europe	Nov-44	US	Ger	4	3,223	2,665	92,393	28,382	0.87%	2.35%

Theater	Date	Nations Attkr	Dfdr	Days	Casualties Attkr	Dfdr	Attacker Men	Defender Men	Attacker Cas. Rate	Defender Cas. Rate
W.Europe	Nov-44	US	Ger	2	185	141	10,348	6,519	0.89%	1.08%
W.Europe	Nov-44	US	Ger	8	2,279	4,942	88,941	32,396	0.32%	1.91%
W.Europe	Nov-44	US	Ger	2	58	224	7,935	5,366	0.37%	2.09%
W.Europe	Nov-44	US	Ger	1	56	233	15,871	6,299	0.35%	3.70%
W.Europe	Nov-44	US	Ger	3	110	216	16,232	6,713	0.23%	1.07%
W.Europe	Nov-44	US	Ger	2	482	811	90,078	30,712	0.27%	1.32%
W.Europe	Dec-44	US	Ger	2	234	129	19,773	6,044	0.59%	1.07%
W.Europe	Dec-44	US	Ger	2	835	1,774	89,977	31,501	0.46%	2.82%
W.Europe	Dec-44	US	Ger	1	155	121	15,224	5,044	1.02%	2.40%
W.Europe	Dec-44	Ger	US	2	268	134	10,000	8,634	1.34%	0.78%
W.Europe	Dec-44	Ger	US	6	4,306	1,731	87,000	19,996	0.82%	1.44%
W.Europe	Dec-44	Ger	US	3	3,000	1,151	36,678	4,840	2.73%	7.91%
E.Europe	Jan-43	USSR	Ger	7	28,000	4,150	120,000	30,000	3.33%	1.98%
E.Europe	Jul-43	Ger	USSR	3	1,364	5,680	62,000	45,000	0.73%	4.21%
E.Europe	Jul-43	Ger	USSR	1	3,180	4,900	140,000	75,000	2.27%	6.53%
E.Europe	Jul-43	Ger	USSR	4	3,500	25,800	60,000	149,000	1.46%	4.33%
E.Europe	Jul-43	Ger	USSR	5	2,900	30,200	56,000	129,000	1.04%	4.68%
E.Europe	Jul-43	USSR	Ger	2	5,700	5,100	78,000	82,300	3.65%	3.10%
E.Europe	Aug-43	USSR	Ger	21	117,700	39,500	980,600	280,000	0.57%	0.67%
E.Europe	Sep-43	USSR	Ger	3	11,676	2,405	70,000	15,000	5.56%	5.34%
E.Europe	Jan-44	USSR	Ger	41	79,000	36,500	524,724	210,000	0.37%	0.42%
E.Europe	Jan-44	USSR	Ger	25	63,500	68,000	254,950	84,500	1.00%	3.22%
E.Europe	Jan-44	USSR	Ger	6	610	480	25,100	8,230	0.41%	0.97%
E.Europe	May-44	USSR	Ger	5	35,500	48,500	397,600	72,000	1.79%	13.47%
E.Europe	Jun-44	USSR	Ger	5	670	4,795	16,100	8,500	0.83%	11.28%
E.Europe	Jul-44	USSR	Ger	17	37,400	198,000	1,200,000	900,000	0.18%	1.29%
E.Europe	Jul-44	USSR	Ger	1	980	720	39,000	3,300	2.51%	21.82%
E.Europe	Jul-44	USSR	Ger	1	1,750	490	38,500	12,900	4.55%	3.80%
E.Europe	Jul-44	USSR	Ger	3	1,150	320	12,700	5,100	3.02%	2.09%
E.Europe	Aug-44	USSR	Ger	6	3,040	785	17,550	6,400	2.89%	2.04%
E.Europe	May-44	USSR	Ger	1			35,170	13,725	0.00%	0.00%
E.Europe	Aug-44	USSR	Ger	10	135,000	690,000	1,250,000	800,000	1.08%	8.63%
E.Europe	Jan-45	USSR	Ger	23	46,900	147,400	2,200,000	560,000	0.09%	1.14%
E.Europe	Jan-45	USSR	Ger	19	112,000	126,000	1,220,000	780,000	0.48%	0.85%
E.Europe	Jan-45	USSR	Ger	1	685	145	10,800	3,100	6.34%	4.68%
E.Europe	Jan-44	USSR	Ger	1	850	230	12,115	3,900	7.02%	5.90%
E.Europe	Apr-45	USSR	Ger	2	474	150	13,600	3,710	1.74%	2.02%
Pacific	Nov-43	US	Jap	4	3,302	4,836	9,000	4,836	9.17%	25.00%
Pacific	Feb-45	US	Jap	5	6,845	15,615	33,915	18,300	4.04%	17.07%
Pacific	Feb-45	US	Jap	5	510	1,231	3,200	1,600	3.19%	15.39%
Pacific	Mar-45	US	Jap	6	3,885	2,685	32,000	2,685	2.02%	16.67%
Pacific	Apr-45	US	Jap	3	158	628	22,888	1,400	0.23%	14.95%
Pacific	Apr-45	US	Jap	4	286	2,120	18,398	2,900	0.39%	18.28%
Pacific	Apr-45	US	Jap	3	466	1,278	18,111	4,731	0.86%	9.00%
Pacific	Apr-45	US	Jap	5	740	1,661	16,291	2,600	0.91%	12.78%
Pacific	Apr-45	US	Jap	3	269	1,324	14,594	5,000	0.61%	8.83%
Pacific	Apr-45	US	Jap	2	182	814	15,986	4,500	0.57%	9.04%
Pacific	Apr-45	US	Jap	4	398	2,276	15,764	4,050	0.63%	14.05%
Pacific	May-45	Jap	US	2	3,704	339	6,830	15,350	27.04%	1.10%
Pacific	May-45	US	Jap	2	114	1,464	15,109	5,140	0.38%	14.24%
Pacific	May-45	US	Jap	2	170	478	16,043	3,338	0.53%	7.16%
Pacific	May-45	Jap	US	1	1,269	241	4,000	15,777	31.73%	1.53%
Pacific	May-45	US	Jap	2	124	434	15,840	3,000	0.39%	7.23%

Theater	Date	Nations Attkr	Nations Dfdr	Days	Casualities Attkr	Casualities Dfdr	Attacker Men	Defender Men	Attacker Cas. Rate	Defender Cas. Rate
Pacific	May-45	US	Jap	3	182	2,564	15,205	2,600	0.40%	32.87%
Pacific	Jun-45	US	Jap	3	193	1,222	16,091	3,500	0.40%	11.64%
Pacific	Jun-45	US	Jap	3	248	1,470	16,002	2,500	0.52%	19.60%
Pacific	Jun-45	US	Jap	1	48	2,401	5,237	2,500	0.92%	96.04%
Pacific	Jun-45	US	Jap	3	317	1,971	15,808	2,000	0.67%	32.85%
Pacific	Apr-45	US	Jap	3	282	1,588	19,082	2,000	0.49%	26.47%
Pacific	Apr-45	US	Jap	4	555	2,470	18,388	2,900	0.75%	21.29%
Pacific	Apr-45	US	Jap	4	1,079	2,468	21,247	3,000	1.27%	20.57%
Pacific	Apr-45	US	Jap	5	879	2,860	17,163	3,000	1.02%	19.07%
Pacific	Apr-45	US	Jap	4	479	3,810	18,095	3,900	0.66%	24.42%
Pacific	May-45	US	Jap	3	502	4,038	19,714	5,284	0.85%	25.47%
Pacific	May-45	US	Jap	5	590	4,328	20,973	4,757	0.56%	18.20%
Pacific	May-45	US	Jap	2	313	3,022	19,658	4,227	0.80%	35.75%
Pacific	Jun-45	US	Jap	4	112	798	18,777	4,000	0.15%	4.99%
Pacific	Jun-45	US	Jap	2	88	1,066	18,660	4,250	0.24%	12.54%
Pacific	Jun-45	US	Jap	6	576	3,220	19,047	3,250	0.50%	16.51%
Viet Nam	Mar-72	NVN	SVN	30		14,300	30,000	17,000		2.80%
Korea	Sep-50	NKor	US	2	110	430	11,000	15,200	0.67%	1.89%
Korea	Sep-50	US	NKor	4	380	940	16,600	10,300	0.57%	2.28%
Korea	Sep-50	US	NKor	3	230	1,640	16,400	9,000	0.47%	6.07%
Korea	Sep-50	US	NKor	6	100	1,350	16,200	7,100	0.10%	3.17%
Korea	Mar-51	US	NKor	3	250	6,120	25,500	27,000	0.33%	7.56%
Korea	Feb-51	US	NKor	5	300	15,810	29,000	30,200	0.21%	10.47%
Korea	Apr-51	US	NKor	3	150	1,560	26,000	12,500	0.19%	4.16%
Korea	Apr-51	NKor	US	5	5730	470	30,700	26,900	3.73%	0.35%
Korea	Apr-51	US	NKor	4	170	4,780	27,900	35,100	0.15%	3.40%
Korea	Jun-51	NKor	US	2	1,460	150	37,000	13,800	1.97%	0.54%
Korea	Jun-51	US	NKor	2	240	3,160	13,700	35,500	0.88%	4.45%
W.Bank	Apr-48	Is	Jor	10	375	500	3,000	3,600	1.25%	1.39%
W.Bank	Jul-48	Is	Jor	5	150	250	4,500	2,500	0.67%	2.00%
Golan	Jun-48	Syr	Is	5	250	2,500	4,000	2,500	1.25%	20.00%
Golan	Jul-48	Syr	Is	6	250	270	3,000	2,700	1.39%	1.67%
Golan	Oct-48	Is	Syr	3	650	2,100	6,000	6,000	3.61%	11.67%
Sinai	May-48	Is	Egy	2	10	10	2,500	3,000	0.20%	0.17%
Sinai	Jul-48	Is	Egy	5	250	300	2,500	3,000	2.00%	2.00%
Sinai	Dec-48	Is	Egy	3	350	600	6,000	4,000	1.94%	5.00%
Sinai	Dec-48	Is	Egy	10	400	600	4,000	3,000	1.00%	2.00%
Sinai	Oct-56	Is	Egy	3	318	3,000	4,700	4,800	2.26%	20.83%
Sinai	Nov-56	Is	Egy	2	13	300	2,668	3,300	0.24%	4.55%
Sinai	Nov-56	Is	Egy	1	229	3,433	10,000	10,050	2.29%	34.16%
Sinai	Nov-56	Is	Egy	1	121	1,987	4,000	6,400	3.03%	31.05%
W.Bank	Jun-67	Is	Jor	1	225	200	10,900	6,160	2.06%	3.25%
W.Bank	Jun-67	Is	Jor	3	1,750	1,500	27,682	13,600	2.11%	3.68%
W.Bank	Jun-67	Is	Jor	2	375	350	12,800	9,900	1.46%	1.77%
W.Bank	Jun-67	Is	Jor	1	250	250	5,350	5,450	4.67%	4.59%
W.Bank	Jun-67	Is	Jor	1	375	350	10,700	8,640	3.50%	4.05%
Jordan	Mar-68	Is	Jor	1	201	497	11,940	16,168	1.68%	3.07%
Sinai	Jun-67	Is	Egy	1	700	2,700	19,520	19,520	3.59%	13.83%
Sinai	Jun-67	Is	Egy	1	90	1,350	10,450	10,050	0.86%	13.43%
Sinai	Jun-67	Is	Egy	1	300	900	19,280	18,450	1.56%	4.88%
Sinai	Jun-67	Is	Egy	1	135	225	6,350	12,750	2.13%	1.76%
Sinai	Jun-67	Is	Egy	1	70	450	10,800	3,000	0.65%	15.00%
Sinai	Jun-67	Is	PLO	3	55	626	12,150	17,450	0.15%	1.20%

Theater	Date	Nations Atkr	Dfdr	Days	Casualties Atkr	Dfdr	Attacker Men	Defender Men	Attacker Cas. Rate	Defender Cas. Rate
Sinai	Jun-67	Is	Egy	1	60	550	8,700	3,000	0.69%	18.33%
Sinai	Jun-67	Egy	Is	1	550	90	22,000	7,250	2.50%	1.24%
Sinai	Jun-67	Is	Egy	1	75	550	10,200	13,500	0.74%	4.07%
Sinai	Jun-67	Is	Egy	1	60	625	18,780	18,450	0.32%	3.39%
Sinai	Jun-67	Egy	Is	1	450	60	3,500	3,600	12.86%	1.67%
Golan	Jun-67	Is	Syr	1	300	850	5,375	8,160	5.58%	10.42%
Golan	Jun-67	Is	Syr	1	150	300	5,350	4,350	2.80%	6.90%
Golan	Jun-67	Is	Syr	1	230	500	5,850	8,560	3.93%	5.84%
Golan	Jun-67	Is	Syr	1	50	500	11,400	9,080	0.44%	5.51%
Golan	Jun-67	Is	Syr	1	50	500	16,500	19,300	0.30%	2.59%
Golan	Jun-67	Is	Syr	1	50	500	17,550	16,767	0.28%	2.98%
Sinai	Oct-73	Egy	Is	1	400	275	29,490	4,435	1.36%	6.17%
Sinai	Oct-73	Egy	Is	1	800	450	63,910	14,000	1.25%	3.21%
Sinai	Oct-73	Egy	Is	1	350	225	22,850	3,020	1.53%	7.45%
Sinai	Oct-73	Egy	Is	1	750	400	45,160	10,980	1.66%	3.64%
Sinai	Oct-73	Is	Egy	1	700	700	25,850	67,440	2.71%	1.04%
Sinai	Oct-73	Egy	Is	1	1,700	380	81,160	43,400	2.09%	0.88%
Sinai	Oct-73	Egy	Is	1	1,350	260	57,960	28,600	2.33%	0.91%
Sinai	Oct-73	Is	Egy	2	100	500	22,790	30,970	0.22%	0.81%
Sinai	Oct-73	Is	Egy	2	950	2,400	28,900	36,840	1.64%	3.26%
Sinai	Oct-73	Is	Egy	1	300	800	19,600	18,180	1.53%	4.40%
Sinai	Oct-73	Is	Egy	4	600	1,800	17,000	23,860	0.88%	1.89%
Sinai	Oct-73	Is	Egy	3	300	1,650	16,200	35,623	0.62%	1.54%
Sinai	Oct-73	Is	Egy	2	150	1,100	16,200	25,600	0.46%	2.15%
Sinai	Oct-73	Is	Egy	2	150	1,100	11,700	22,570	0.64%	2.44%
Sinai	Oct-73	Is	Egy	2	340	1,100	14,681	22,570	1.16%	2.44%
Sinai	Oct-73	Is	Egy	1	75	400	10,900	14,620	0.69%	2.74%
Golan	Oct-73	Syr	Is	2	350	200	17,750	3,630	0.99%	2.75%
Golan	Oct-73	Syr	Is	2	700	250	22,750	5,745	1.54%	2.18%
Golan	Oct-73	Syr	Is	1	350	250	19,525	4,958	1.79%	5.04%
Golan	Oct-73	Syr	Is	1	500	150	21,984	6,300	2.27%	2.38%
Golan	Oct-73	Syr	Is	2	500	250	12,500	6,946	2.00%	1.80%
Golan	Oct-73	Is	Syr	3	450	1,125	17,833	23,750	0.84%	1.58%
Golan	Oct-73	Is	Syr	3	450	1,125	12,733	14,683	1.18%	2.55%
Golan	Oct-73	Syr	Is	2	1,200	400	31,650	5,395	1.90%	3.71%
Golan	Oct-73	Is	Syr	1	50	100	2,692	1,583	1.86%	6.32%
Golan	Oct-73	Is	Syr	3	525	1,200	16,100	19,400	1.09%	2.06%
Golan	Oct-73	Is	Syr	2	280	900	14,700	21,500	0.95%	2.09%
Golan	Oct-73	Irq	Is	1	450	50	12,500	14,300	3.60%	0.35%
Golan	Oct-73	Is	Irq	1	100	200	11,000	12,000	0.91%	1.67%
Golan	Oct-73	Jor	Is	1	450	100	11,500	11,000	3.91%	0.91%
Golan	Oct-73	Syr	Is	1	550	160	35,750	16,100	1.34%	0.99%
Golan	Oct-73	Is	Syr	1	150	200	5,700	4,750	2.63%	4.21%
Golan	Oct-73	Is	Syr	1	100	250	11,400	4,750	0.88%	5.26%
Lebanon	Jun-82	Is	Syr	3	1,082	4,150	34,500	25,000	1.05%	5.53%

TECHNICAL DATA ASSESSMENT

1. Casualty Rate Calculations.

The attacker casualty rates were calculated for each battle as the percentage of attacker casualties per day using the following formula:

$$\frac{(\#\text{ of Attacker Casualties} / \#\text{ of Attacker Men})}{\#\text{ of Days of Battle}}$$

Similarly, the defender casualty rates were calculated as the percentage of defender casualties per day for each battle using the formula:

$$\frac{(\#\text{ of Defender Casualties} / \#\text{ of Defender Men})}{\#\text{ of Days of Battle}}$$

The casualty rates were formulated as a percentage of casualties per day to control for sizes of force and length of battle.

2. Descriptive Statistics and Normality of Data.

The attacker casualty rates involved 251 battles with a mean rate of 1.8% and a median rate of .9%. The minimum attacker casualty rate was .1% and the maximum attacker casualty rate was 31.7%.

The defender casualty rate data involved 253 battles with a mean of 5.7% and a median of 2.8%. The minimum defender casualty rate was .1% while the maximum was 96%.

A Kolmogorov - Smirnov (K & S) Goodness of Fit Test was performed for a normal distribution on both the attacker and defender casualty rates. Both sets of data had a $p<.001$. Thus, the hypothesis that the data sets are normal was rejected at a 95% confidence level and it was concluded that the attacker and defender casualty rates were not normal distributions.

3. Data Grouped by Decades.

The attacker and defender casualty rates were grouped by decades to include the 1940's, 50's, 60's, and 70's. Because the data is not from a normal distribution, a nonparametric test, the Kruskal - Wallis test, was used to test if any significant differences existed among the median casualty rates grouped by decades. This procedure requires ranking the data and comparing the mean ranks of the groups. A confidence level of 95% was used. Thus, if the significance level was found to be less than .05, we conclude there are differences among both the attacker and

defender casualty rates grouped by decades. The results of the test follow:

Attacker Casualty Rate Grouped by Decade

Mean Rank	# of Cases	Decade
115.91	172	40's
94.27	15	50's
145.93	23	60's
149.67	33	70's
	243	Total

Corrected for Ties

Chi-Square	Significance
11.4057	.0097

Defender Casualty Rate Grouped by Decade

Mean Rank	# of Cases	Decade
117.42	172	40's
154.13	15	50's
151.39	23	60's
110.76	33	70's
	243	Total

Corrected for Ties

Chi-Square	Significance
8.7289	.0331

Since .0097 and .0331 are less than .05, we conclude a difference does exist among the decades for both postures of casualty rates. The analysis was continued to determine which decades differed. This involved a simultaneous multiple comparison of the decades with an overall confidence level of 80%. In order for a difference to be significant at this overall level, the differences between mean ranks must have differed by the amounts shown in the following matrix. These values vary from comparison to comparison due to the differences in the number of cases among decades.

Significant Difference Required Between Mean Ranks

	40	50	60	70
40	0			
50	40.27	0		
60	33.21	49.64	0	
70	28.43	46.58	40.63	0

The differences among mean ranks for the two casualty rate postures are as follows:

Differences Among Attacker Casualty Rates

	40	50	60	70
40	0			
50	-21.64	0		
60	30.02	51.66*	0	
70	33.76*	55.40*	3.74	0

Differences Among Defender Casualty Rates

	40	50	60	70
40	0			
50	36.71	0		
60	33.97*	-2.74	0	
70	-6.66	-43.37	-40.63*	0

* indicates that a significant difference exists among these decades.

In comparing the attacker casualty rate, the analysis revealed that the median casualty rates of the 40's < 70's, the 50's < 60's, and the 50's < 70's. Within the defender casualty rates, the only significant difference among decades was the 40's < 60's and 60's > 70's.

4. Data Grouped by Wars.

The data was also grouped by wars, although very little variation from the results of the groupings by decades was expected. The five different groups classified by war were the data from World War II, the 48 Israeli War, the Korean War, the 67 Israeli War, and the 73 Israeli War. Again a Kruskal - Wallis test was used to determine if significant differences exist within the attacker and defender casualty rates among wars. The data was ranked and grouped by war. A 95% confidence level was used to determine if a significant difference exists among wars. The results are listed below.

Attacker Casualty Rate Grouped by War

Mean Rank	# of Cases	War
117.82	170	WWII
141.44	9	48 Israeli
71.50	11	Korean
145.87	23	67 Israeli
149.61	33	73 Israeli
	246	Total

Corrected for Ties

Chi-Square	Significance
14.2449	.0066

Defender Casualty Rate Grouped by War

Mean Rank	# of Cases	War
120.98	171	WWII
121.78	9	48 Israeli
134.27	11	Korean
156.26	23	67 Israeli
114.35	33	73 Israeli
	247	Total

Corrected for Ties

Chi-Square	Significance
5.8334	.2119

Since .2119 > .05, we failed to conclude that a significant difference exists among the median defender casualty rates grouped by war. Conversely, since .0066 < .05, we concluded that a significant difference does exist among the median attacker casualty rates grouped by war. A simultaneous multiple comparison, with a family confidence level of .80, was performed on the attacker posture. There was no need to do a multiple comparison on the defender posture since we were unable to show that a difference existed among wars. The matrix below shows the amounts by which the mean ranks must have differed in order for a significant difference to exist among wars.

Significant Difference Required Between Mean Attacker Ranks

	WWII	48 Israel	Korean	67 Israel	73 Israel
WWII	0				
48 Israeli	56.61	0			
Korean	51.49	74.39	0		
67 Israeli	36.77	65.08	60.68	0	
73 Israeli	31.48	62.24	57.62	44.96	0

The differences among mean ranks grouped by war for the attacker casualty rates are:

Differences Among Attacker Casualty Rates

	WWII	48 Israel	Korean	67 Israel	73 Israel
WWII	0				
48 Israeli	23.62	0			
Korean	-46.32	-69.94	0		
67 Israeli	28.05	4.43	74.37*	0	
73 Israeli	31.79*	8.17	78.11*	3.74	0

* indicates that a significant difference in the median attacker casualty rates exists between these wars.

In comparing the attacker casualty rates by war, the analysis revealed that the median casualty rate for World War II < 73 Israeli War, the Korean War < 67 Israeli War, and the Korean War < 73 Israeli War.

5. Ungrouped Casualty Rates from 1937 - 1983.

A statistical analysis was performed analyzing the data on an individual basis to determine if a trend (upward or downward) exists between the historical casualty rate postures and the battle dates from 1937 - 1983. Both the dates and the casualty rates were ranked on an ordinal scale and a nonparametric test, the Spearman's Rank Correlation test, was performed to determine if a trend does in fact exist. The Spearman's Rank Correlation coefficient (r) for casualty rate postures paired with the battle date must yield a value between $\pm$ .12385 to fail to conclude at a 95% level of significance that no trend or association exists. Pairing the attacker casualty rates with the battle dates produced an r = .00488, thus we were unable to conclude that a trend exists between the attacker casualty rates and battle dates from 1937 - 1983. However, pairing the defender casualty rates with the battle dates yielded an r = .277. Using a correction factor for ties, r = .267. In this case, we can conclude that an upward trend does exist between defender casualty rates and battle dates from 1937 - 1983. It should be noted that although this test statistic does conclude that a trend exists, because r < .3, this indicates that the magnitude or degree of association is low.

REFERENCES

Dupuy, Trevor N., et. al., Analysis of Factors That Have Influenced Outcomes of Battles and Wars: A Database of Battles and Engangements, Vol IV- VI. Historical Evaluation and Research Organization, Dunn Loring, VA., Sept., 1984.

Dupuy, Trevor N., Numbers, Predictions, & War. Bobbs-Merril, Indianapolis, IN., 1979.

Gibbons, Jean Dickinson, Nonparametric Methods for Quantitative Analysis. American Sciences Press, Columbus, OH., 1976.

Helmbold,R.L., Do Battles and Wars Have a Common Relationship Between Casualties and Victories? Concepts Analysis Agency, Bethesda, MD., July 1988.

Kuhn, George W. S., Ground Forces Casualty Rate Patterns. Logistics Management Institute, Bethesda, MD., Sept., 1989.

McQuie, Robert, Historical Characteristics of Combat for Wargames (Benchmarks). Concepts Analysis Agency, Bethesda, MD., July, 1988.

Myers, Raymond and Walpole, Ronald, Probability and Statistics for Engineers and Scientists. McMillian and Publishers, New York, N.Y., 1985.